10/582917

AP3 Rec'd PCT/PTO 13 JUN 2006

DOCKET NO.: 4948
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TITLE: Gas Turbine, Particularly an Aircraft Engine

TRANSLATOR'S DECLARATION

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solemnly declare:

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PCT International Application PCT/DE2004/002572, as filed on 20. November 2004

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: May 29, 2006

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ACCURATE LITERAL TRANSLATION OF PCT INTERNATIONAL APPLICATION PCT/DE2004/002572 AS FILED ON 20 NOVEMBER 2004

Gas Turbine, Particularly an Aircraft Engine

The invention relates to a gas turbine, particularly an aircraft engine according to the preamble of patent claim 1.

In addition to the forward thrust for advancing the aircraft, aircraft engines, whether commercial aircraft engines or military aircraft engines, also produce energy for the supply of attachment devices and secondary aggregates, respectively, of the gas turbine or for the supply of aircraft-borne systems such as an air conditioning system. The attachment devices, secondary aggregates or even aircraft-borne systems of an aircraft engine can be hydraulic, pneumatic or also electric or electric motor driven devices, aggregates or systems.

A clear trend can be recognized in the development of aircraft that ever more electrical energy is required in an aircraft. This requirement is due on the one hand to the fact that hydraulically or pneumatically operated attachment devices or auxiliary aggregates of the gas turbines are being replaced by attachment devices or auxiliary aggregates that are driven by an electric motor. On the other hand, an ever increasing energy requirement is necessary for each seat in the aircraft. The aircraft engines thus must make available an ever increasing electrical power or rather an ever increasing electrical energy.

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Such aircraft engines are also referred to as "More Electric Engine" (MEE).

For producing electrical energy to be supplied to attachment devices or auxiliary aggregates of the gas turbine as well as to the aircraft-borne systems it is known in the prior art to pick up mechanical energy from the core engine of a gas turbine for example for driving pumps or generators. German Patent Publication DE 41 31 713 C2 shows an aircraft engine wherein shaft power is taken off from the core engine. This shaft power is supplied to auxiliary aggregates.

According to the state of the art, generators for producing electrical energy are constructed as auxiliary aggregates or as attachment devices of the gas turbine. Thus, these items are constructed as separate structural units and mounted outside of the area of the actual gas turbine.

Starting from the above it is the object of the present invention to construct a new gas turbine, particularly a new aircraft engine.

This object has been achieved in that the above mentioned gas turbine has been further developed in accordance with the features of the characterizing portion of patent claim 1. According to the invention, the generator is integrated into the inside of the gas turbine in such a way that the or each rotor of the generator is allocated to the rotor and the or each stator

of the generator is allocated to the stator of the engine. Thus kinetic energy of the rotor is convertible by the generator into electric energy.

In accordance with the present invention it is suggested to integrate the generator for producing electrical energy into the interior of the gas turbine. Thereby, a simplification of the construction of a gas turbine constructed as a "More Electric Engine" is achieved.

According to an advantageous further development of the invention, the or each rotor of the generator is allocated to the rotor shaft of the rotor whereby the or each rotor comprises several pole pieces which are secured to the rotor shaft either as a unit or individually. The or each stator of the generator is then preferably allocated to a stator-side bearing block of the rotor shaft.

In accordance with an alternative advantageous further development of the invention, the or each rotor of the generator is allocated to the rotor blades of the rotor whereby pole pieces are integrated into the rotor blades or the pole pieces are allocated to the ends of the rotor blades. The or each stator of the generator is then preferably allocated to the housing of the stator and/or to the stationary guide vanes of the stator.

Preferably control means make it possible to operate the generator as a motor for starting the gas turbine and to use the

generator for producing electrical energy after the start of the gas turbine. Extra electrical energy of the gas turbine is preferably supplyable to the gas turbine for driving the rotor of the gas turbine while the generator operates as a motor.

Preferred further embodiments of the invention are defined by the dependent subclaims and in the following description.

Example embodiments of the invention are described in more detail with reference to the accompanying drawings, without being limited thereto. The figures show:

Fig. 1 a schematized portion of a cross section through a gas turbine according to the invention in accordance with a first example embodiment of the invention;

Fig. 2 a detail of the arrangement according to Fig. 1 in a front view; and

Fig. 3 a schematized portion of a cross section of a gas turbine according to the invention in accordance with a second example embodiment of the invention.

The present invention will be described in the following with greater detail with reference to Figures 1 to 3.

Fig. 1 shows a partial cross section through a high pressure compressor 10 of a gas turbine, whereby the high pressure

compressor 10 comprises a rotor and a stator. In the illustrated example embodiment, the rotor comprises a rotor shaft 11 which drives a total of three rotor discs 12, 13 and 14. Rotor blades 15 are arranged on each of the rotor discs 12, 13 and 14 positioned next to each other in the circumferential direction. The rotor blades 15 rotate together with the rotor discs 12, 13 and 14. The rotor blades 15 allocated to a rotor disc 12 or 13 or 14 form so called rotor blade rings. The rotor blade rings are arranged one behind the other in the throughflow direction or in the axial direction of the high pressure compressor 10. The rotor blade rings are formed by the rotor disc 12, 13 and 14 and the corresponding rotor blades 15. An arrow 16 indicates in Fig. 1 the through flow direction of the high pressure compressor 10. Thus, the rotor of the high pressure compressor 10 is formed at least by the rotor shaft 11, the rotor discs 12, 13 and 14 and the rotor blades 15.

The stator of the high pressure compressor 10 comprises a housing 17 and guide vanes 18. The guide vanes 18 and the housing 17 are constructed to be stationary. The guide vanes 18 form guide vane rings which are arranged one behind the other just as the rotor blade rings, in the throughflow direction (arrow 16) of the high pressure compressor 10. Thereby, one rotor blade ring of rotating rotor blades 15 is arranged between two respective neighboring guide vane rings made of stationary guide vanes 18. The rotor blade rings thus rotate relative to the stationary housing and relative to the also stationary guide vane rings.

According to the invention a generator 19 is integrated into the high pressure compressor 10. The generator 19 is thereby integrated into the interior of the high pressure compressor 10 in such a way that a rotor 20 is allocated to the rotor and a stator 21 is allocated to the stator. The kinetic energy of the rotor can be converted by the generator 19 into electrical energy. In the example embodiment shown in Fig. 1, the rotor 20 of the generator 19 is allocated to the rotor shaft 11 of the high pressure compressor 10. The stator 21 of the generator 19 is allocated to a bearing block 22 of the rotor shaft 11. The bearing block 22 is positioned on the stator side.

In the example embodiment of Fig. 1, the generator 19 is constructed as a transversal flow machine according to the principle of a so called "Switched Reluctance Machine". The stator 21 of the generator 19 is formed in this case by two partial stators 23 and 24. Each of the two partial stators 23 and 24 is secured to the bearing block 22 and comprises a complete set of windings 25. The two partial stators 23 and 24 of the generator 19 are spaced from each other in the axial direction of the gas turbine. The rotor 20 of the generator 19 rotates between these two partial stators 23 and 24 of the generator 19.

The rotor 20 of the generator 19 is preferably secured to the rotor shaft 11 of the rotor as shown in Fig. 2. In the example embodiment of Fig. 2, the rotor 20 comprises a total of eight pole pieces 26 constructed as soft iron poles. The pole pieces

26 are interconnected with each other at their radially inwardly located ends 27 by an element 28 formed as a hollow cylinder. The inner diameter of the hollow cylinder element 28 is adapted to the outer diameter of the rotor shaft 11 so that the rotor 20 of the generator 19 can be stuck or mounted as a unit onto the rotor shaft 11 to be connected with the rotor shaft.

However, other methods of securing the rotor on the rotor shaft 11 are possible as distinguished from the illustrated example embodiment. Thus, the pole pieces of the rotor of the generator can be secured individually to the rotor shaft 11 in that the pole pieces are directly secured to the rotor shaft 11 with their radially inwardly positioned ends.

As already mentioned, in the example embodiment of the Fig. 1 the generator 19 is constructed as a transversal flow machine. In distinction to Fig. 1, Fig. 3 shows that a generator 29 can also be integrated into the high pressure compressor 10 which compressor is constructed as a so called drum or cylindrical rotor machine. The example embodiments according to Figs. 1 and 3 are distinguished from each other only by the concrete construction of the generator. Therefore, the same reference numbers are used for the same structural groups and reference is made to the explanations with respect to Fig. 1.

Also in the example embodiment of Fig. 3 a rotor 30 of the generator 29 is allocated to the rotor shaft 11 and a stator 31 is allocated to the bearing block 22 of the high pressure

compressor 10. In the example embodiment of Fig. 1 the rotor 20 of the generator 19 rotates between two partial stators 23 and 24 positioned with an axial spacing from each other. On the other hand, in the example embodiment of Fig. 3 the rotor 30 rotates relative to a stator 31 which encloses the rotor 30 in the radial direction. Compared to the example embodiment of Fig. 3 in which the generator 29 is constructed as a drum rotor machine, the embodiment of Fig. 1 in which the generator 19 is constructed as a transversal flow machine has the advantage that the air gap between the rotor 20 and the stator 21 is not changed by expansions of the rotor 20 caused by centrifugal force and heat. However, in the example embodiment of Fig. 1, compared to the example embodiment of Fig. 3, it is disadvantageous that the two partial stators 23 and 24 attract each other so that these stators must accordingly be secured to the bearing block 22 with a sufficient force take-up. Thus, the example embodiment of Fig. 1 as well as the example embodiment of Fig. 2 have certain advantages.

It is further in accordance with the present invention to allocate control means to the gas turbine or to the illustrated high pressure compressor 10 or both. These control means make it possible, on the one hand, to operate the generator 19 or 29 as a generator for producing electrical energy from the kinetic energy of the rotor and, on the other hand, to operate the generator as a motor for driving the rotor shaft 11 on the basis of available electrical energy. More specifically, it is within the sense of the present invention to operate the generator 19

or 29 not only for producing electrical energy but also for driving the rotor shaft 11. Using the generator 19 or 29 in a motor operation comes particularly into consideration for starting the gas turbine. Thus, the rotor shaft 11 of the high pressure compressor 10 can be driven up to a rated rpm with the aid of the generators 19 or 20 by supplying electrical energy. Following the starting, the generator 19 or 29 is then used for producing electrical energy by way of the control means.

It is also in accordance with the present invention integrate not only a generator 19 or 29 into the high pressure compressor 10 in the manner as described above but rather it is possible to integrate a generator into a low pressure compressor not shown. If respective generators are integrated into the high pressure compressor as well as into the low pressure compressor, it is in accordance with the present invention to couple the generators of the high pressure compressor and of the low pressure compressor with each other. Thereby, it is possible to provide for a power equalization between the high pressure compressor and the low pressure compressor. For example, if the generator of the high pressure compressor produces more electrical energy than is necessary, then it is possible in this case to use the generator of the low pressure compressor in a motor operation in order to use the excess electrical energy for driving the rotor shaft of the low pressure compressor. Heretofore, according to the prior art, it was necessary to use-up the excess electrical energy as lost heat in a resistor unit. In accordance with the present invention, it is possible to return such excess

electrical energy into the gas turbine as kinetic energy to thereby improve the overall efficiency of the gas turbine. It is also conceivable, in the case in which the generator of the low pressure compressor produces too much electrical energy, to return this excess electrical energy to the high pressure compressor in that the generator of the high pressure compressor is then operated as a motor and the excess electrical energy of the generator of the low pressure compressor is used for driving the rotor shaft of the high pressure compressor.

In accordance with the present invention it is further suggested that the windings 25 of the stators 21 or 31 of the generators 19 or 29 are cooled with fuel. Thus, it is within the teachings of the invention to construct the windings 25 as hollow conductor windings and to feed the fuel through these hollow windings for cooling. The fuel flowing through the windings 25 can then be further conducted to fuel injection nozzles in the area of the combustion chamber of the gas turbine. Such a cooling of the windings 25 of the stators 21 or 31 by fuel permits an especially efficient cooling of the windings thereby obviating the conventional expensive oil cooling.

Figs. 1 and 3 show only a partial axial longitudinal section through the high pressure compressor 10 so that in Figs. 1 and 3 only that portion of the high pressure compressor 10 is seen that extends above the rotor shaft 11. The structural components shown in Figs. 1 and 3 extend around the rotor shaft 11 in the circumferential direction. In order to make possible a simpler

mounting of the stators 21 and 31 of the generators 19 or 29 it is suggested in accordance with a further aspect of the present invention to construct the stators 21 and 31 respectively in at least two sections. Each of the two stator sections of the stators 21 and 31 would extend around the rotor shaft 11 for 180° in the circumferential direction in a two-part embodiment. Naturally, other divisions are also possible whereby the angular or circumferential extension is automatically determined by the division of the stators 21 and 31. In order to make possible a division of the stators 21 and 31, two measures are suggested according to the present invention. As a first measure, the windings 25 of the stators 21 and 31 respectively are to be constructed as wave windings. According to a second measure it is suggested to select the number of stator slots or grooves, the number of poles, the stator diameter and other generator design parameters in such a way that only one winding is required for each stator slot and that each stator section carries the entire required number of windings which are necessary for generating the electrical energy. It has thus also been recognized according to the present invention that by constructing the windings as wave windings in combination with the requirement that only one winding is provided for each stator slot, it becomes possible to divide the stator 21 and 31 respectively of the generator 19 or 29 as divided sections. This feature makes it possible to noticeable simplify the assembly of the gas turbine.

In the illustrated example embodiments, all the rotors 20 and 30 respectively, of the generators 19 or 29, respectively, are allocated to the rotor shaft 11 and the stators 21 and 31, respectively, are all allocated to bearing blocks 22 of the rotor shaft 11. In distinction from the illustrated embodiment it is also possible to allocate the rotor of the generator to the rotating rotor blades. Pole pieces constructed as soft iron poles may, for example, be allocated to the radially outwardly positioned ends of the rotating rotor blades to rotate together with the rotor blades relative to the stationary housing and the also stationary guide vanes. In this case it is necessary that the rotating rotor blades are constructed in such a way that they safely take up the additional centrifugal forces caused by the soft iron poles. In the case in which the pole pieces of the rotor are allocated to the rotating rotor blades, the stator of the generator is allocated either to the stationary guide vanes or to the stationary housing of the stator of the gas turbine. In this manner it is also possible to integrate a generator into the gas turbine.